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Compensation Costs of Work-Related Back Disorders Among Union Carpenters, Washington State 1989–2003

Hester J. Lipscomb, PhD,[1]* John M. Dement, PhD, CIH,[1] Barbara Silverstein, PhD, MPH, CPE,[2] Wilfrid Cameron, MS, CIH,[3] and Judith E. Glazner, MS[4]

Background *We measured resources used to provide medical care and to estimate lost productivity represented by payments for lost work time or impairment for work-related back injuries among a large cohort of union carpenters over 15 years.*

Methods *Using administrative data we identified a cohort of carpenters, their hours worked, their workers' compensation claims and associated costs. After adjustment for inflation and discounting to 2006 dollars, yearly costs for injuries and payment rates based on hours worked were calculated. Using negative binomial regression, dollars paid per claim were modeled based on age, gender, union tenure, and predominant type of work of the carpenter and whether the injury resulted from overexertion or acute trauma.*

Results *Workers' compensation costs for back injuries exceeded $128 million dollars between 1998 and 2003, representing payments of $0.97 for each hour of work. Costs per hour of work declined substantively over time due largely to declining overexertion injury rates. Traumatic injuries, though less common than overexertion injuries, were more expensive. Costs increased with the number of prior back injuries and with increasing age, beginning as early as age 30.*

Conclusions *Increasing costs even among relatively young carpenters likely reflect the heavy nature of their work rather than simply the effects of biological aging. Musculoskeletal back problems remain a common, and consequently costly, source of injury among these carpenters that needs to be addressed through engineering modifications; there are also clearly needs for prevention of the often more costly back injuries associated with acute trauma.* Am. J. Ind. Med. 52:587–595, 2009. © *2009 Wiley-Liss, Inc.*

KEY WORDS: work-related back disorders; musculoskeletal; costs (health care, indemnity, impairment); construction workers; carpenters; workers'compensation

BACKGROUND

For decades back pain has been among the most common reasons for work absenteeism and a leading cause of work disability and activity limitation among young adults [Deyo and Tsui-Wu, 1987; Kelsey and Hochberg, 1988; US Department of Labor BLS, 2000]. Back pain remains one of the most expensive health care problems among working adults with costs reported to vary by cause of event and industry sector [Cheadle et al., 1994; Hashemi et al., 1997; Murphy and Courtney, 2000].

Capturing the full burden of work-related back injuries and disorders is challenging given the growing

[1]Division of Occupational and Environmental Medicine, Department of Community and Family Medicine, Duke University Medical Center, Durham, North Carolina
[2]Department of Labor and Industries, State of Washington, Safety and Health Assessment and Research for Prevention Program (SHARP), Olympia, Washington
[3]Center for Construction Research and Training (Center to Protect Workers' Rights), Silver Spring, Maryland
[4]Department of Health Systems, Management and Policy, University of Colorado Health Sciences Center, Denver, Colorado
Contract grant sponsor: NIOSH (Back Disorders in Union Carpenters); Contract grant number: R01 OH 008007.
*Correspondence to: Hester J. Lipscomb, P.O. Box 3834, Duke University Medical Center, Durham, NC 27710. E-mail: hester.lipscomb@duke.edu

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documentation from a number of reports that indicate Bureau of Labor Statistics data from the Annual Survey significantly under-estimate risk to workers in the U.S. [Azaroff et al., 2002; Leigh et al., 2004; Rosenman et al., 2006]. Workers' compensation records provide an alternative and valuable source of information on injuries reported by workers, employers or health care providers as being related to work, and they provide a way to capture the associated medical care, indemnity and impairment costs of these injuries. Analyses of such costs can provide an estimate of injury severity as well as economic burden, not discernible in injury-rate data [Rice, 2000]. However, workers compensation coverage is provided in most states by multiple carriers, making access to claims data for large groups of workers difficult to obtain, particularly over an extended period of time. Furthermore, workers' compensation data alone typically fail to provide information on the population at risk.

Carpenters have exposures to recognized occupational risk factors for back pain—heavy work, materials handling, pushing, twisting, frequent heavy lifting, requirements for sudden unexpected maximal effort, and awkward postures [Schneider and Susie, 1994]. With increasing work demands related to the use of heavier, bulkier materials such as 12–16 foot sheets of drywall weighing over 100 pounds per sheet and heavy laminated beams, it is not surprising that their injury rates are high [Lipscomb et al., 2008a]. Back injuries are responsible for nearly 20% of nonfatal injuries with days away from work in the construction industry [CPWR, 2008]. The primarily heavy nature of construction work also limits opportunities for modified work or accommodation following injury.

The goal of these analyses was to measure the resources used to provide medical care and to estimate lost productivity represented by payments for lost work time or impairment for back injuries among a large cohort of union carpenters over a 15-year period, 1989 to 2003. By analyzing these data we also sought to evaluate sub-groups of injured carpenters whose injuries were responsible for higher costs as well as to estimate costs associated with injury based on hours worked by the cohort.

MATERIALS AND METHODS

Data Sources

Using data from the Carpenters Trusts of Western Washington (CTWW) we identified a cohort of union carpenters who worked in the State of Washington between 1989 and 2003, inclusive, their dates of birth, gender, earliest date of union activity, and their hours of union work. The Washington State Department of Labor and Industries (L&I) provided the workers' compensation claims for the cohort. The data were provided with a blinded unique identifier, allowing us to merge the records on an individual basis without the use of personal identifiers; these methods have been previously described in detail elsewhere [Lipscomb et al., 1997, 2000, 2003]. No race or ethnicity information was available from these sources. Cohort membership was limited to individuals who worked at least 3 months of union hours during this 15-year period and had at least 1 month of eligibility for health insurance through CTWW.

The State of Washington has a state-administered worker's compensation program that captures medical-only claims as well as those that result in lost work time. In addition to date of injury and standard compensation codes (body part injured, injury nature, the type of event causing the injury), the L&I data include the costs incurred for medical care, indemnity, and impairment. Claims from companies that self-insure for compensation coverage are coded in the L&I data only if they result in paid lost time from work; these self-insured claim records do not contain complete cost data. Data were extracted on August 26, 2004 allowing 8 months after the last claims were filed in 2003 for fuller development of the claims, proper identification, and capture of the self-insured claims that resulted in paid lost time.

Adjustment for Inflation and Discounting

Our cost data spanned 15 years. To compare costs incurred during different years and express them in constant dollars, it is necessary to adjust them for inflation and discount them. We used the consumer price index (CPI) for the nation, adjusting all costs (medical, indemnity, impairment) for inflation to the year 2006. Medical costs were adjusted using the CPI for medical care. Those adjusted costs were then discounted by 3% per year to account for changes in the time value of money over the study period. These procedures account for differences in the values of services received or payments made at different time periods, yielding the present value of each cost stream or grouping thereof [Drummond et al., 1999]. These two adjustments resulted in all costs being expressed in constant dollars as of the year 2006. All WC costs were assigned to the year in which the injury occurred. In the event a workers' compensation claim was still open, projected claim reserve costs were used.

Analyses

Using previously identified work-related back injuries among this cohort [Lipscomb et al., 2008a], the distribution of cost was examined separately for medical care, indemnity and impairment. Mean and median costs (payments) per claim were calculated by year and by whether the claim was the first back injury for the carpenter or a subsequent injury. Payments associated with back injuries resulting from acute

trauma (falls, struck by, etc.) were analyzed separately from those associated with overexertion injuries (lifting, pushing, pulling, manual materials handling, etc.).

Negative binomial regression was used to model payments and adjusted payment ratios allowing us to assess risk of higher costs among the injured carpenters. The use of generalized linear models in analyses of medical care costs has been previously described to accommodate factors that are typical of cost data, including highly skewed distributions, and the variability that often increases as mean costs increase rather than having a constant variance (homoscedasticity) [Blough and Ramsey, 2000]. Finally, payment rates expressed as dollars per hours worked for the entire cohort were calculated by year to assess trends in overall cost burden of back injuries among these construction workers. All analyses were conducted using SAS Version 8.2 [SAS Institute, Inc., 1999].

RESULTS

Between 1989 and 2003, 4,138 workers' compensation claims for back injuries/disorders were filed by a cohort of 18,768 union carpenters in the State of Washington. These carpenters worked a total of 134,199,443 work hours over the 15-year period. The cohort, the compensation claims, and claim rates have been previously described in detail [Lipscomb et al., 2008a]. The distribution of hours worked by age, gender, union tenure and predominant type of work of the local with which each carpenter affiliated, as well as the number of injuries caused by overexertion and acute traumatic events (falls, struck by, motor vehicle accident) are presented in Table I.

TABLE I. Distribution of Hours Worked, Overexertion and Acute Back Injuries by Age, Gender, Union Tenure and Predominant Type of Work, Union Carpenters, Washington State 1989–2003

	Hours worked	Overexertion	Acute trauma
Age			
<30	22,545,628	589	204
30 to <40	47,457,445	1,282	426
40 to <50	41,745,886	799	327
50 to <60	22,288,337	363	139
Gender			
Male	131,773,547	2,965	1,068
Female	2,260,386	65	27
Time in the union			
<2 years	17,183,794	533	186
2 to <4 years	14,888,280	441	140
4 to <6 years	11,659,061	268	123
6 to <8 years	9,409,159	224	95
8 to <10 years	8,843,898	205	64
10 years and over	72,203,905	1,371	488
Predominant work			
Heavy commercial	20,253,804	407	164
Drywall	24,129,911	837	272
Residential	1,675,730	59	26
Millwright	2,549,160	50	32
Pile driver	8,171,203	87	30
Out of Washington	1,826,138	38	18
Mixed commercial	58,917,900	1,098	378
Light commercial	14,919,760	374	143

Total costs incurred for back injuries/disorders including medical care, indemnity payments for lost time, and impairment for this cohort of carpenters were $128,358,522, representing $0.97 for each hour of work. This figure includes estimated costs for 5% of claims that were not closed at the time the data were obtained; less than one percent of claims from 1989 were still open compared to 22% of those from 2003. Indemnity payments were responsible for the largest proportion of costs followed by medical care for both overexertion injuries and those caused by acute trauma (Table II). Cost per claim was significantly higher for injuries resulting from acute trauma ($45.6 thousand; 95% CI, 40.7, 51.0) than for those resulting from overexertion ($25.0 thousand; 95% CI, 23.3, 26.8); traumatic injuries were responsible for 26% of claims and 39% of total costs.

While mean costs of work-related back injuries ended slightly lower in 2003 than in 1989, there was significant variability over the 15-year period with no discernable trend. Lower acute injury costs were responsible for this slight decline in costs over time (not at a level of statistical significance); no change in mean costs of overexertion injuries was observed (Fig. 1). In each year, indemnity payments were consistently responsible for the largest proportion of costs associated with these injuries (Fig. 2). The data were highly skewed with median costs for indemnity and impairment equal to zero in each year; median medical costs ranged from a high of $1,700 in 1990 to a low of $1,050 in 1998, but ended in 2003 at $1,600 as they were in 1989.

Costs and adjusted cost ratios for overexertion and acute back injuries followed similar patterns with costs increasing with increasing age (Table III). It is of note that similar patterns were seen for both indemnity and medical costs, although the cost ratios were slightly higher for indemnity (data not shown). Costs for women were higher than costs for men for both overexertion and acute injuries, but these estimates were based on few observations and are consequently unstable. Minimal differences were observed based on predominant type of work with the exception of relatively low costs for overexertion injuries among pile drivers.

For overexertion injuries particularly, payments tended to increase as the number of back injuries experienced

TABLE II. Distribution of Workers' Compensation Payments for Back Injuries by Injury Type Among Union Carpenters, Washington State, 1989–2003, Expressed in 2006 Dollars

	Overexertion (n = 3,042)	Acute (n = 1,096)	Overall (n = 4,138)
Medical			
Total	27,501,931 (35.3%)	18,254,797 (36.2%)	45,756,728
Mean	9,041	16,656	11,058
Median	1,231	1,885	1,373
Indemnity[a]			
Total	43,283,694 (55.6%)	26,784,073 (53.1%)	70,067,767
Mean	35,333	77,872	41,023
Median	4,156	55,454	6,180
Impairment[b]			
Total	7,116,554 (9.1%)	5,417,481 (10.7%)	12,534,026
Mean	18,876	23,152	13,377
Median	18,538	20,074	18,971
Overall			
Total	77,902,170 (100%)	50,456,351 (100%)	128,358,522
Mean	25,608	46,037	31,019
Median	1,669	2,497	1,864

[a]Limited to 1,708 or 41.3% of claims with paid lost time.
[b]Limited to 611 or 14.8% of claims with impairment.

increased up to the third injury (Table IV) after adjusting for calendar time as well as age, gender, tenure, and type of work. This pattern of increasing cost is even more pronounced when analyses are limited to individuals who had a subsequent injury (Table V). Among the 233 carpenters who experienced three back injuries mean medical and impairment costs were over three times higher for the third injury than the first and indemnity costs were over seven times higher.

Although mean costs for back injuries changed relatively little over 15 years, payment rates based on dollars spent per hour of work decreased markedly over time (Fig. 3).

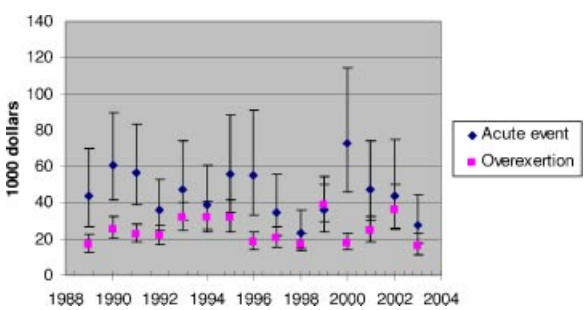

FIGURE 1. Yearly mean workers' compensation payments (dollars in 2006 value) and 95% confidence limits for back injuries attributed to overexertion and acute trauma among union carpenters, Washington State, 1989–2003.

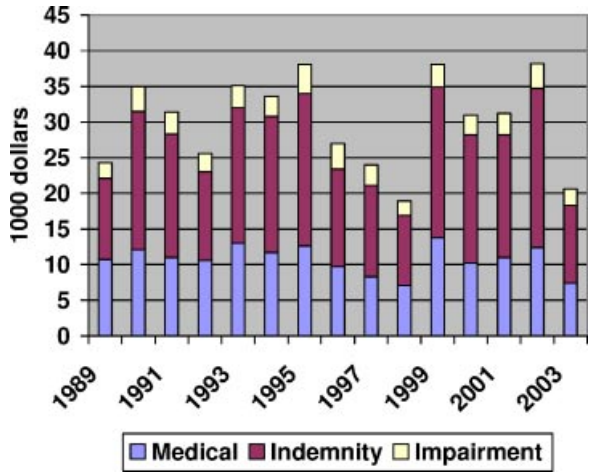

FIGURE 2. Total workers' compensation payments (dollars in 2006 value) for work-related back injuries (n = 4,138) among 18,768 union carpenters in Washington State, 1989–2003.

Dollars spent on back injuries per hour of carpenter work decreased from a high of $1.61 per hour in 1990 to $0.39 per hour in 2003 representing less than one quarter of the 1990 cost rate.

DISCUSSION

Through the use of multiple sources of administrative data that could be linked on an individual basis, we described payments for back disorders through the workers' compensation system among a large cohort of union carpenters in the State of Washington. Using these data we were able to compare patterns of resource use over time and among different sub-groups of workers based on age, union tenure, and their predominant type of work, as well as for different mechanisms of injury.

The analyses confirm a significant, but decreasing, economic burden for back injuries reported through the workers' compensation system among these union carpenters for both medical care and lost work time. The decline reflects both declining costs associated with acute back injuries over time as well as the previously described decrease in overexertion injury rates among this cohort between 1989 and 2003 [Lipscomb et al., 2008a]. Acute back injuries were responsible for a disproportionate share of costs among these carpenters compared with overexertion injuries consistent with patterns seen in other industries as well as construction [Murphy and Courtney, 2000].

Some of the adjusted cost ratios we report contrast with earlier described patterns of injury risk among this cohort. For example, younger carpenters and those with less union tenure have higher rates of back injuries [Lipscomb et al., 2008a], while payment rates are higher among injured older carpenters.

TABLE III. Payments* and Adjusted Payment Ratios** for Overexertion and Acute Back Injuries (Among the Injured), Union Carpenters, Washington State, 1989–2003

	Overexertion injuries		Acute traumatic injuries	
	Payments* in $1,000's per injury (95% CI)	Adjusted payment ratio (95% CI)**	Payments* in $1,000's per injury (95% CI)	Adjusted payment ratio (95% CI)**
Age				
<30	16.6 (14.2, 19.4)	1	31.8 (24.2, 41.7)	1
30 to <40	24.4 (23.8, 29.4)	1.62 (1.29, 2.05)	39.9 (33.3, 47.9)	1.24 (0.82, 1.88)
40 to <50	26.1 (22.8, 29.8)	1.71 (1.31, 2.23)	48.3 (39.3, 59.4)	1.64 (1.03, 2.62)
50 to <60	31.3 (25.5, 38.7)	2.11 (1.49, 3.00)	78.7 (56.4, 109.9)	2.76 (1.51, 5.05)
Gender				
Male	24.9 (23.2, 26.7)	1	45.3 (40.3, 50.9)	1
Female	28.6 (17.8, 46.1)	1.23 (0.69, 2.19)	57.7 (27.7, 120.0)	1.62 (0.65, 4.00)
Time in the union				
<2 years	20.1 (17.0, 23.8)	1	40.1 (30.2, 53.2)	1
2 to <4 years	19.3 (16.1, 23.1)	0.92 (0.71, 1.19)	31.0 (22.4, 42.9)	1.21 (0.76, 1.92)
4 to <6 years	27.7 (22.1, 34.8)	0.92 (0.70, 1.20)	39.5 (27.9, 42.9)	0.70 (0.44, 1.12)
6 to <8 years	32.3 (25.1, 41.6)	1.33 (0.97, 1.81)	47.2 (32.1, 69.2)	1.10 (0.67, 1.81)
8 to <10 years	30.1 (23.2, 39.0)	1.54 (1.10, 2.17)	50.5 (31.5, 80.8)	1.15 (0.68, 1.92)
10 years and over	26.1 (23.5, 28.9)	1.28 (0.91, 1.80)	52.3 (44.0, 62.1)	1.29 (0.68, 2.44)
Predominant work				
Heavy commercial	26.6 (22.1, 32.0)	1	47.8 (35.7, 64.1)	1
Drywall	25.1 (22.1, 28.5)	0.92 (0.71, 1.20)	39.1 (31.1, 49.1)	0.94 (0.60, 1.47)
Residential	26.9 (16.5, 43.8)	0.93 (0.50, 1.71)	21.3 (10.1, 44.9)	0.50 (0.19, 1.35)
Millwright	30.3 (17.8, 51.3)	0.95 (0.49, 1.82)	54.0 (28.0, 104.4)	1.46 (0.59, 3.58)
Pile driver	16.3 (10.9, 24.5)	0.52 (0.30, 0.87)	34.8 (17.6, 68.8)	0.91 (0.37, 2.24)
Out of Washington	26.3 (14.3, 48.2)	0.92 (0.44, 1.93)	37.1 (15.0, 91.8)	0.88 (0.28, 2.72)
Mixed commercial	23.8 (21.2, 26.7)	0.88 (0.68, 1.13)	51.5 (42.5, 62.5)	1.21 (0.80, 1.85)
Light commercial	27.3 (22.7, 31.2)	1.03 (0.75, 1.41)	45.5 (33.2, 62.2)	0.86 (0.51, 1.44)

*Dollars (in 2006 dollar value) modeled as counts using negative binomial regression.
**Adjusted for age, gender, tenure, and type of work; scaled deviance.

TABLE IV. Payments* and Adjusted Payment Ratios** for Overexertion and Acute Back Injuries (Among the Injured), by the Number of Claims of the Worker, Union Carpenters, Washington State, 1989–2003

	Overexertion injuries		Acute traumatic injuries	
	Payments* in $1,000's per injury (95% CI)	Adjusted payment ratio (95% CI)**	Payments* in $1,000's per injury (95% CI)	Adjusted payment ratio (95% CI)**
Count of claims				
First claim	22.3 (20.5, 24.2)	1	44.7 (39.1, 51.0)	1
Second claim	30.5 (26.1, 35.6)	1.27 (1.02, 1.59)	50.2 (37.6, 67.1)	1.39 (0.92, 2.11)
Third claim	38.1 (28.5, 50.9)	1.88 (1.30, 2.22)	52.6 (32.4, 85.6)	1.27 (0.68, 2.37)
Fourth claim +	29.9 (20.1, 44.4)	1.43 (0.87, 2.36)	28.4 (13.4, 50.0)	0.53 (0.20,1.38)

*Dollars (in 2006 dollar value) modeled as counts using negative binomial regression.
**Adjusted for age, gender, tenure, type of work, and calendar time; scaled deviance.

TABLE V. Mean Payments (Dollars in 2006 Value) (and Standard Errors) by Order of Injury Occurrence, Work-Related Back Injuries Union Carpenters Washington State, 1989–2003

	Payments (SE)		
	First injury (n = 3,037)	**Second injury (n = 751)**	**Third injury (n = 233)**
Medical	10,470 (532)	12,456 (1,155)	14,875 (1,907)
Indemnity	15,682 (854)	19,420 (1,935)	25,325 (3,937)
Impairment	2,989 (1,433)	3,130 (308)	3,604 (598)

	First injury	**Second injury**
Limited to those who had subsequent injury		
751 carpenters who had at least two back injuries		
Medical	4,118 (401)	12,456 (1,155)
Indemnity	3,932 (1,155)	19,420 (1,935)
Impairment	1,062 (647)	3,130 (308)

	First injury	**Second injury**	**Third injury**
Limited to those who had subsequent injury			
233 carpenters who had at least 3 back injuries			
Medical	4,015 (567)	9,021 (1,996)	14,875 (1,907)
Indemnity	3,207 (753)	10,753 (2,423)	25,325 (3,937)
Impairment	1,056 (288)	1,538 (412)	3,604 (598)

It is fairly well recognized that age is associated with delayed return to work following injury and this cohort is no exception [Kucera et al., in preparation]. Older workers may not be more at risk of injury, but when they do experience injuries, the consequences are more severe. For example, workers over 45 years of age who sustain a work-related back injury requiring time away from work are less likely to return to work than younger workers [Oleinik et al., 1996; Gluck and Oleinick, 1998; Dasinger et al., 1999; McIntosh et al., 2000]. It is of note that among these carpenters, indemnity payment rates increased with increasing age as did medical payment rates, providing some indication that the injuries of older workers may be more severe and that older workers may be more difficult, or less likely, to be accommodated in this heavy industry.

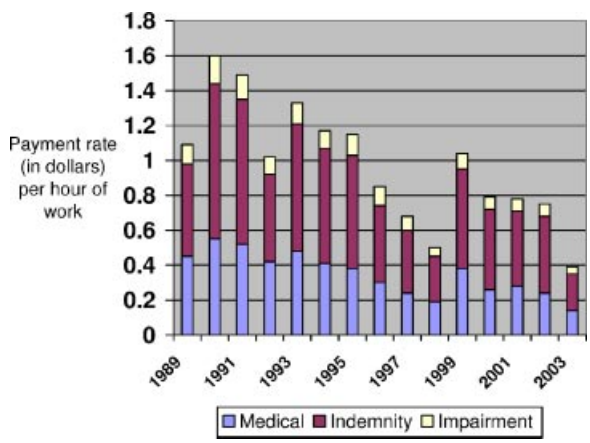

FIGURE 3. Yearly workers' compensation payment rates (dollars in 2006 value) per hour of work among union carpenters Washington State, 1989–2003.

Return to work may mark the end of the first episode of work disability [Baldwin et al., 1996], but many people with back problems continue to have problems which require modification of activities [Von Korff, 1994; Carey, 1995; Pransky et al., 2000]. Among this cohort we saw increasing costs associated with second and third back injury claims, particularly if they were of a musculoskeletal nature as well as very high costs among the small group of carpenters who experienced multiple back injuries. Prevention of additional injuries via accommodation may be important to prevent subsequent more expensive injuries.

These findings are consistent with the disproportionate burden of costs from recurrent back pain related to care seeking and work disability among workers in multiple industries in New Hampshire reported by Wasiak et al. [2006]. While secondary prevention may be warranted, among these workers we have been unable to identify factors that are strongly associated with recurrent back injuries other than prolonged work disability with the initial injury [Lipscomb et al., 2008b]. With only 5% of these injured carpenters experiencing a month or more of time away from work with their first injury, targeted secondary prevention that will have substantive impact on costs among this population is difficult to operationalize.

Strengths and Limitations

In contrast to concerns about the possibility that non work-related medical care may be paid for by the workers' compensation system, it is possible, and perhaps more likely, for the reverse to happen in this group. These carpenters, unlike many non-union construction workers, have health insurance coverage through a jointly trusted health and welfare fund developed through collective bargaining processes. Contractors hiring union labor pay into the trust based on the hours worked by the workers they hire; these funds are used to support health insurance coverage and retirement benefits. In Washington State health insurance coverage for eligible carpenters is free; eligibility is based on working a required number of hours each quarter. Once they initially meet the requirement, workers are allowed to bank hours to extend their coverage at times when work may not be steady as is often the case in construction. These carpenters describe the ease of seeking care outside the compensation system for injuries that are not likely to keep them out of work, and they express concerns about retaining employment if they have a history of filing WC claims for minor injuries. These health care funds have traditionally had close alliances with the populations they serve; some report that seeking care through their private union-provided insurance is less difficult than dealing with workers' compensation.

In light of this information, our cost estimates for work-related back disorders are likely to be under-estimated and may represent, at least to some degree, cost-shifting [Ducatman, 1986; Zwerling et al., 1991; Butler et al., 1997] to their union-provided health insurance coverage. It is of note that among this cohort we have observed an increase in health care utilization for back disorders of a musculoskeletal nature covered through their health care trust as the rate of reported work-related overexertion back injuries declined [Lipscomb et al., in press]. Even though the union health insurance has been constant over this time period, factors which might influence reporting have been subject to change over this 15-year period. These include, but are not limited to, fluctuations in the construction economy creating more precarious employment as well as resulting pressure to cut compensation costs [Azaroff et al., 2002, 2004] including incentives from contractors that reward supervisors and/or workers for reduction of work-related injury rates [Pransky et al., 1999].

A major strength of this work was the ability to clearly define a large retrospective 15-year cohort of carpenters, their workers' compensation claims and associated costs. The data linkage was made possible through collaboration with the Carpenters' Trusts of Western Washington and the Washington State Department of Labor and Industries.

These data however, lack any direct exposure information. We know that the assignment of predominant type of work based on the union local with which each carpenter affiliates results in some misclassification which may be responsible, at least in part, for the lack of discernable cost differences based on type of work.

Actual WC payments were used in these analyses. A great advantage of using payments to measure resource use, particularly for medical care, is that no adjustments for different charge structures among providers must be made. Typically, insurance plans and workers' compensation plans pay for medical care according to a negotiated fee structure [employing a conversion factor and current procedural terminology (CPT) units (for clinic or physician care) or Diagnosis Related Group (DRG) weights (for inpatient care)]; this obviates adjusting charges submitted by different clinics, hospitals or providers to an estimate of cost, which is a more accurate measure of resource use than are charges. An important virtue of the use of medical fee structures based on CPT codes and DRGs is that they include measures of work involved for each activity or diagnosis, thereby approximating resource use; moreover, these fee structures have considerable internal validity. The general linear modeling we used, did not require transforming the skewed cost data and retransforming back to dollars for interpretation thereby avoiding the associated potential bias [Manning, 1998; Mullahy, 1998; Blough and Ramsey, 2000].

Work-loss costs, or productivity losses, consist primarily of the costs to employers and workers associated with time taken from work to receive treatment or to recover from injuries. There is some controversy among researchers about the sources of productivity costs as well as methods used to measure them [Rothermich and Pathak, 1999]. We used a variation of the human capital method, the most widely used method for valuing productivity loss. Rather than estimating losses using average wages for the U.S., as is often done, we used the actual standard payments made by workers' compensation for lost work time and scheduled payments made for impairment. These embody to some extent lost productivity due to injury and are more precise than average weekly wage for determining productivity loss. By estimating these payments, we capture some of the societal costs of back injury. However, we were unable to capture losses to the worker or indirect costs.

Lastly, 5% of claims remained open when the data were obtained and more of these were from recent years. This could cause some underestimation of costs in more recent years and confuse conclusions regarding trends. However, to reduce this error we did use actuarial estimates of payments (for medical, indemnity, and impairment) for open claims.

CONCLUSIONS

Workers' compensation costs for back injuries have decreased substantively among this cohort of union carpenters over 15 years due in large part to declining injury rates.

The changes observed in the costs of caring for and accommodating the carpenters with back injuries may be more significant than they first appear given that spine-related health care expenditures in the U.S. have increased substantially during this time period [Martin et al., 2008]. Older workers, whose injuries are responsible for higher costs, face challenges in returning to work following back injuries that can result in long-term activity limitations. Such concerns have been raised regarding our aging workforce in general, but among these construction workers costs began increasing among those in their 30s and continued to increase steadily with increasing age. This likely also reflects the generally heavy nature of their work rather than simply the effects of biological aging. While musculoskeletal back problems remain a common, and consequently costly, source of injury among these carpenters that needs to be addressed through engineering modifications, there is also a need for measures to prevent the often more costly back injuries associated with acute trauma.

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REFERENCES

Azaroff LS, Levenstein C, Wegman DH. 2002. Occupational injury and illness surveillance: Conceptual filters explain underreporting. Am J Public Health 92:1421–1429.

Azaroff LS, Lax MB, Levenstein C, Wegman DH. 2004. Wounding the messenger: The new economy makes occupational health indicators too good to be true. Int J Health Serv 34(2):271–303.

Baldwin MJ, Johnson WG, Butler RJ. 1996. The error of using returns-to-work to measure the outcomes of health care. Am J Indus Med 29:632–641.

Blough DK, Ramsey SD. 2000. Using generalized linear models to assess medical care costs. Health Serv Outcomes Res Methodol 1(2): 185–202.

Butler RJ, Hartwig RP, Gardner H. 1997. HMO's, moral hazard and cost shifting in workers' compensation. J Health Econ 16:191–206.

Carey TS, Evans A, Hadler N, Kalsbeek W, Mclaughlin C, Fryer J. 1995. Care-seeking among individuals with chronic low back pain. Spine 20(3):312–317.

Cheadle A, Franklin G, Wolhagen C, Savarino J, Liu PY, Salley C, Weaver M. 1994. Factors influencing the duration of work-related disability: A population-based study of Washington State Workers' Compensation. Am J Public Health 84(2):190–196.

Center to Protect Workers' Rights. The Construction Chart Book: The U.S. Construction Industry and its Workers. CPWR—The Center for Construction Research and Training. MD: Silver Spring. 2008.

Dasinger LK, Krause N, Deegan LJ, Brand RJ, Rudolph L. 1999. Duration of work disability after low back injury: A comparison of administrative and self-reported outcomes. Am J Indus Med 36:619–631.

Deyo RA, Tsui-Wu Y. 1987. Descriptive epidemiology of low-back pain and its related medical care in the United States. Spine 12(3):264–268.

Drummond MF, O'Brien B, Stoddart GL, Torrance GW. Methods for the economic evaluation of health care programmes. 2nd edition. New York: Oxford University Press. 1999.

Ducatman A. 1986. Workers' compensation cost-shifting; a unique concern of providers and purchasers of prepaid health care. J Occup Med 28(11):1174–1176.

Gluck J, Oleinick A. 1998. Claim rates of compensable back injuries by age, gender, occupation, and industry: Do they relate to return-to-work experience? Spine 23(14):1572–1587.

Hashemi L, Webster BSD, Clancy EA, Volinn E. 1997. Length of disability and costs of workers' compensation low back pain claims. J Occup Environ Med 39:937–945.

Kelsey JL, Hochberg MC. 1988. Epidemiology of chronic musculoskeletal disorders. Ann Rev Public Health 9:379–401.

Kucera KL, Lipscomb HJ, Silverstein B, Cameron B. In preparation. Delayed return-to-work after work-related back injury among union carpenters. Am J Indus Med.

Leigh JP, Marcin JP, Miller TR. 2004. An estimate of the U.S. Government's undercount of nonfatal occupational injuries. J Occup Environ Med 46:10–18.

Lipscomb HJ, Dement JM, Loomis DP, Silverstein B, Kalat J. 1997. Surveillance of work-related musculoskeletal injuries among union carpenters. Am J Indus Med 32:629–640.

Lipscomb HJ, Dement JM, Gaal J, Cameron W, McDougall V. 2000. Work-related injuries in drywall installation. Appl Occ Environ Hyg 15(10):794–802.

Lipscomb HJ, Dement J, Li L. 2003. Work-related falls among union carpenters in Washington State before and after the vertical fall arrest standard. Am J Indus Med 44(2):157–165.

Lipscomb HJ, Cameron W, Silverstein B. 2008a. Work-related back injuries among union carpenters in Washington State, 1989–2003. Am J Ind Med 51(6):463–474.

Lipscomb HJ, Cameron W, Silverstein B. 2008b. Incident and recurrent back injuries among union carpenters. Occup Environ Med 65:827–834.

Lipscomb HJ, Dement JM, Silverstein B, Kucera KL, Cameron W. 2009. Health care utilization for musculoskeletal back disorders, Washington State union carpenters, 1989–2003. J Occup Environ Med 51(5):604–611.

Manning WG. 1998. The logged dependent variable, heteroscedasticty, and the retransformation problem. J Health Econ 17:283–295.

Martin BI, Deyo RA, Mirza SK, Turner JA, Comstock BA, Hollingsworth W, Sullivan S. 2008. Expenditures and health status among adults with back and neck problems. JAMA 299(6):656–664.

McIntosh G, Frank J, Hogg-Johnson S, Bombardier C, Hall H. 2000. 1999 Young Investigator Research Award Winner: Prognostic factors for time receiving workers' compensation benefits in a cohort of patients with low back pain. Spine 25(2):147.

Mullahy J. 1998. Much ado about two: Reconsidering retransformation and the two-part model in health economics. J Health Econ 17:247–281.

Murphy PL, Courtney TK. 2000. Low back pain disability: Relative costs by antecedent and industry group. Am J Indus Med 37:558–571.

Oleinik A, Gluck JV, Guire KE. 1996. Factors affecting first return to work following a compensable occupational back injury. Am J Indus Med 30:540–555.

Pransky G, Snyder T, Dembe A, Himmelstein J. 1999. Under-reporting of work-related disorders in the workplace: A case study and review of the literature. Ergonomics 42(1):171–182.

Pransky G, Benjamin K, Hill-Fotouhi C, Katz JN, Johnson WG, Himmelstein J, Fletcher KE, Katz J, Johnson W. 2000. Outcomes in work-related upper extremity and low back injuries: Results of a retrospective study. Am J Indus Med 37:400–409.

Rice DP. 2000. Cost of illness studies: What is good about them? Inj Prev 6(3):177–179.

Rosenman KD, Kalush A, Reilly MJ, Gardiner JC, Reeves M, Luo Z. 2006. How much work-related illness and injury is missed by the current national surveillance system? J Occup Environ Med 48:357–365.

Rothermich EA, Pathak DS. 1999. Productivity-cost controversies in cost-effectiveness analysis: Review and research agenda. Clin Ther 21(1):255–267.

SAS Institute, Inc. 1999. The SAS System, Version 8.2. Cary, NC: SAS Institute, Inc.

Schneider S, Susie P. 1994. Ergonomics and construction: A review of potential hazards in new construction. Am Ind Hyg Assoc J 55(7):131.

US Department of Labor Bureau of Labor Statistics. 2000. Nonfatal occupational injuries and illnesses involving days away from work by occupation and selected parts of the body affected by injury or illness.

Von Korff M. 1994. Studying the natural history of back pain. Spine 19(18S):2041S–2046S.

Wasiak R, Kim J, Pransky G. 2006. Work disability and costs caused by recurrence of low back pain; longer and more costly than in first episodes. Spine 31:219–225.

Zwerling C, Ryan J, Orav EJ. 1991. Workers' compensation cost shifting: An empirical study. Am J Indus Med 19:317–325.